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Report No. 2

Western Spruce Budworm Silvicultural Demonstration Area Project, Carson National Forest

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WESTERN SPRUCE BUDWORM SILVICULTURAL DEMONSTRATION AREA PROJECT
Carson National Forest
New Mexico

Report No. 2

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by

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I. INTRODUCTION

The western spruce budworm, Choristoneura occidentalis Freeman, is a major defoliator of Rocky Mountain Douglas-fir, Pseudotsuga menziesii var. glauca, and true firs, Abies spp., throughout the Southwestern, Rocky Mountain, Northern, and Northwestern Regions. Budworm larvae feed principally in buds and on the foliage of the current year. Sustained heavy attacks cause nearly complete defoliation in 3 to 5 years and result in appreciable growth loss, tree deformity, top-killing, and tree mortality. Cone and seed production are also significantly reduced.

Past research, along with innumerable observations by field foresters, suggests that silvicultural practices can have a decided effect on the amount of stand damages caused by the western spruce budworm. For example, tree damages can be minimized by: (1) favoring intolerant species in silvicultural treatments, since it is always the more shade tolerant host which suffers the greater damage (Williams 1966, 1967; Williams et al. 1971; Johnson and Denton 1975); (2) thinnings and other types of stocking reduction treatments would result in less budworm damage by improving tree growth and reducing competition, since dense stands have been shown to incur more damage by the budworm than open stands (Fauss and Pierce 1969; Williams et al. 1971); and (3) removal of host overstories and favoring even-aged stand structures can be considered preventive management practices for the budworm, since understory host trees are especially vulnerable to budworm damage because of the relatively poor physiological condition, and because they are subject to inundation by larvae dropping from the host overstory trees (Johnson and Denton 1975).

In 1980, the Carson National Forest, in conjunction with Forest Pest Management and with the assistance of CANUSA,[1] initiated a silvicultural demonstration area on the Taos Ranger District. The intent of the demonstration area project is to gain a wider acceptance of preventive management strategies for use against the western spruce budworm and other important forest pests while meeting other timber management objectives. Silvicultural management systems demonstrated include (1) clearcutting with planting, (2) shelterwood seed-step cutting with planting, (3) shelterwood seed-step cutting with protection of advanced regeneration, and (4) shelterwood final removal cutting. The cutting and logging phases of this demonstration area project were completed in the spring of 1981; planting will be completed in the spring of 1982.

In 1981, western spruce budworm larval and egg mass densities were sampled on seedlings, saplings, and dominant-codominant sample

[1]The Canada/U.S. Spruce Budworms Program (CANUSA) is an accelerated research and development program chartered to design and evaluate management strategies specifically designed for management of budworm-susceptible forests.

trees on each of the four treatment units and control unit. Defoliation estimates were also determined for dominant-codominant sample trees in all demonstration units except the clearcut unit. These data are summarized in this report.

Posttreatment stand examinations and an indepth damage assessment will be performed in the summer of 1982 after larval feeding is completed.

II. OBJECTIVES

The objectives of this western spruce budworm silvicultural demonstration area project are:

1. To demonstrate the effect of certain state-of-the-art silvicultural systems on resident western spruce budworm populations and on the resultant damage during and subsequent to an ongoing outbreak.

2. To demonstrate the relative effectiveness of these treatments on achieving timber production objectives.

3. To estimate and compare budworm population densities before and after treatment and for 4 to 5 years thereafter until the project is either terminated or the outbreak collapses from natural causes.

4. To display a comparison between the unmanaged forest and various forest management and stand regeneration techniques.

III. DESCRIPTION OF PROJECT AREA

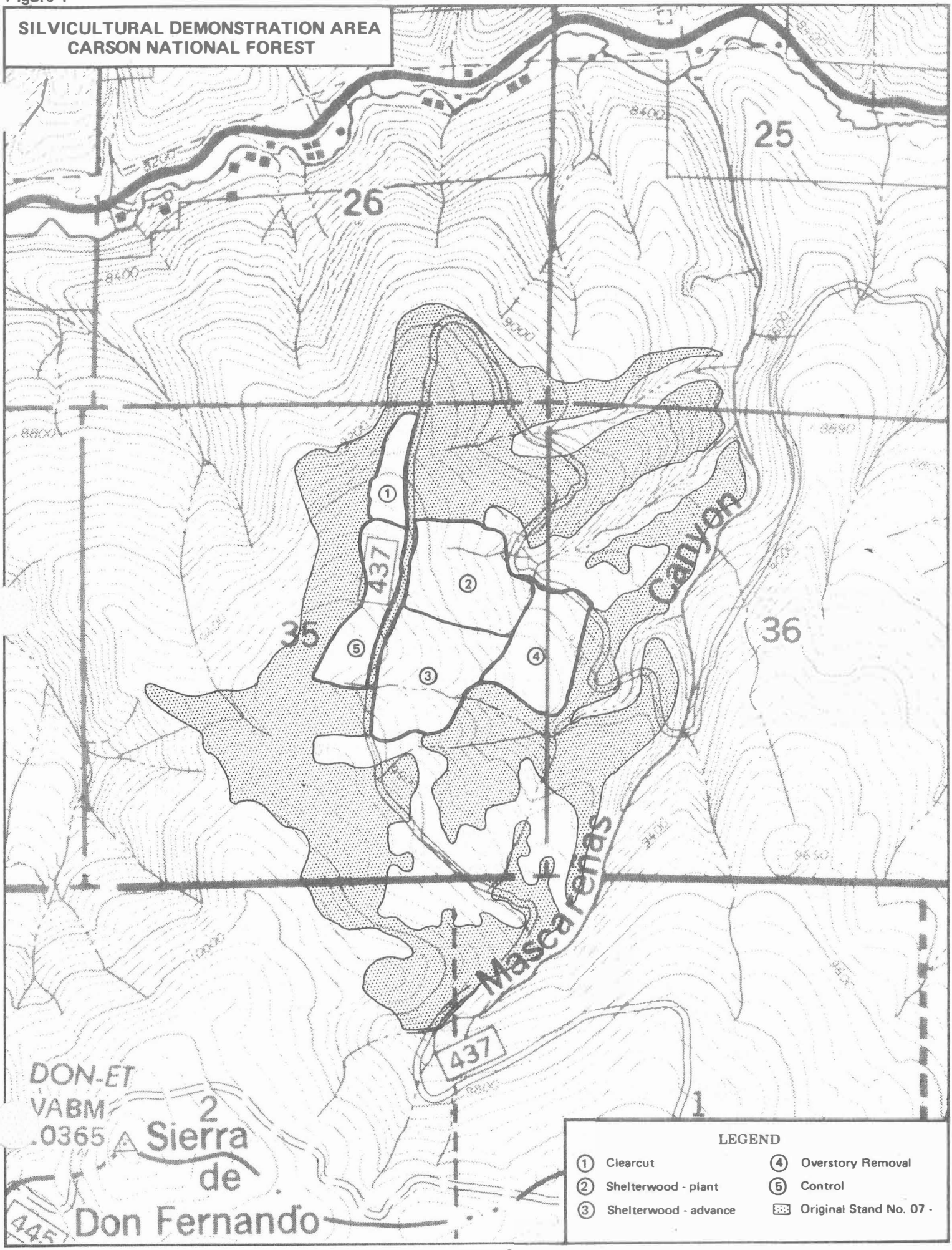
A. Location

The project area is located on the Taos Ranger District of the Carson National Forest (figure 1). It is identified as stand #07 of compartment #206. The stand is situated on a broad ridge which extends north from Don Fernando Peak towards Taos Canyon. Included are side slopes averaging 20 percent and generally facing northeast. The elevation ranges from 8,400 to 9,800 feet.

B. Outbreak History

The project area is currently infested with western spruce budworm as part of a general outbreak which was first detected in 1975. In order to accurately portray the impact of this outbreak, sampling units were installed at selected locations across the Carson National Forest in 1978 (Stein 1980). One such sampling unit is located within the demonstration area. Data from this damage assessment unit indicate that the project area received little or no defoliation prior to 1978. From 1978 to 1979, average current year's defoliation of overstory Douglas-fir rose from 47 to 80 percent. Egg mass densities also rose sharply, indicating that the damage would intensify by 1980.

Figure 1


SILVICULTURAL DEMONSTRATION AREA
CARSON NATIONAL FOREST
25
26
35
36
1
2
437
Mascarenas Canyon
DON-ET
VABM
.0365
Sierra
de
Don Fernando
445
LEGEND
1 Clearcut
2 Shelterwood - plant
3 Shelterwood - advance
4 Overstory Removal
5 Control
Original Stand No. 07 -

C. Pretreatment Stand Conditions

The project area prior to silvicultural treatments consisted of stand variations which are typical of the Southwestern mixed conifer type (Jones 1974) in terms of species composition, size class diversity, and infection level of Douglas-fir dwarf mistletoe (Arceuthobium douglasii). The stand was composed principally of Rocky Mountain Douglas-fir (Pseudotsuga menziesii var. glauca), white fir (Abies concolor), and quaking aspen (Populus tremuloides). Lesser amounts of Engelmann spruce (Picea engelmannii), blue spruce (Picea pungens), and corkbark fir (Abies lasiocarpa var. arizonica) were also found associated with the more mesic sites. Remnant old-growth ponderosa pine (Pinus ponderosa) occurred in two small overwood groups.

The stand had an irregular age-size class structure which was caused primarily by prior extensive salvage harvesting. The broken overstory was formed by mature and overmature sawtimber. Scattered poletimber occurred under this layer as did seedlings and saplings. Understory stocking was improved where canopy openings and past ground disturbance occurred.

Douglas-fir dwarf mistletoe, the western spruce budworm, and certain fungal diseases are the most important debilitating agents in the stand. The dwarf mistletoe (Arceuthobium douglasii) occurrs throughout the stand, but was extremely severe in the northern and western portions. In these areas, nearly all Douglas-fir trees, regardless of size or position, showed brooming, whereas elsewhere this response was scattered in the overwood. Feeding damage by the western spruce budworm (Choristoneura occidentalis) was most apparent in the suppressed, overtopped white fir, Douglas-fir, and Engelmann spruce. Less damage occurred to seedlings and saplings growing in openings or under quaking aspen. Defoliation was quite noticeable in the overstory, but little top-kill or mortality could be attributed to the current infestation. Hypoxylon canker (H. mammatum) and the false tinder fungus (Fomes ignarius) were infecting many aspen clones and inducing windthrow in localized situations. Shoestring root rot (Armillaria mellea) and other unidentified root diseases were found causing crown deterioration and mortality in Douglas-fir and white fir. Indian paint fungus (Echinodontium tinctorium) was causing stem decay in older white fir.

An intensive pretreatment stand examination was performed on the project area during the first week of August 1980 (Wulf and Rogers 1981). The area was first stratified into substands or treatment units based on variations in species composition and stand structure observed on aerial photographs. Following ground reconnaissance, five treatment units were chosen for the demonstration. These are depicted on the project area map (figure 1).

IV. SILVICULTURAL TREATMENTS

Four different silvicultural treatments were conducted on the demonstration area. These treatments represent the full range of

feasible silvicultural options for regenerating an even-aged stand while employing pest protection strategies. Sustained timber production is assumed to be the only management objective for the area. Uneven-aged systems were not proposed because management objectives and such systems are difficult and costly to implement and regulate. The seed tree method was not considered a viable alternative because western spruce budworm is likely to destroy the cone crops of its host species and there are insufficient numbers of ponderosa pine seed trees. The four prescribed treatments are: (1) clearcutting with planting, (2) shelterwood seed-step cutting with planting, (3) shelterwood seed-step cutting with protection of advance regeneration, and (4) shelterwood final removal cutting. Silvicultural prescriptions, with special reference to the implied spruce budworm protection strategies, are described in western spruce budworm silvicultural demonstration area project, report No. 1 (Wulf and Rogers 1981).

V. METHODS

A. Sampling Locations

The project area was divided into four treatment units and one untreated check unit (figure 1). In each of the treated units and the untreated check unit, 10 dominant-codominant Douglas-fir trees, 30 to 50 feet in height and relatively open-grown with full crowns, were selected for sampling. Sample trees were used for obtaining information on larval and egg mass densities and defoliation, and were located as close to stand examination plot centers as possible. Plot centers were established systematically using a 10-point sampling grid. Distances between plot centers were determined by the size of the unit being sampled.

Douglas-fir seedlings and saplings were also sampled on each stand examination plot.

B. Larval Sampling

Larval sampling began when 20 percent of the larvae were in the fifth instar or larger. On each dominant-codominant sample tree, two 15-inch branches were cut from opposite sides of the midcrown using a pole pruner with attached collecting bag. The length and width of each branch were recorded to determine the foliated branch surface area.

Each branch sampled was positioned over a drop cloth and beat with a stick until all the larvae were dislodged; larvae in the collecting bag were removed by inverting the bag over the drop cloth and vigorously shaking it. The larvae were counted and preserved in ethyl alcohol. One bottle was used to preserve all the larvae collected from the 10 sample trees in each unit.

Bottles containing the preserved larvae were then labeled with the appropriate unit and collection date. Total numbers of larvae and live buds per 15-inch branch were counted and recorded.

Seedlings ranging from 1.5 to 3 feet tall were sampled by bending them over a drop cloth and beating them with a stick until all larvae were dislodged. The larvae and total number of live buds were counted and recorded. Saplings, ranging from 1 inch to 4.99 inches in d.b.h., were sampled by removing 2 branches from the midcrown using a pole pruner with attached collecting bag. Each branch was then positioned over drop cloth as previously described. The larvae and number of live buds per branch were counted and recorded, and then discarded.

C. Egg Mass Sampling

In early August, egg masses on overstory trees were sampled by cutting two 70 cm branches from opposite sides of each sample tree. Branches were cut using a pole pruner. The length and width of each branch were measured to calculate foliated branch surface area. Each branch was then individually bagged in a 1/4-bushel cloth sack, labeled, transported to the laboratory, and stored in a walk-in cooler at 40° F prior to examination.

Foliage was examined under ultraviolet light for egg masses. Needles bearing egg masses were classed as from current year's foliage or previous year's foliage and kept in separate pill boxes. New egg masses were separated from old egg masses under a stereomicroscope. All egg masses on current year's foliage were classed as new and their characteristics were used to form the basis for aging egg masses found on previous year's foliage.

Egg masses of seedlings and saplings were sampled by cutting one branch from their respective midcrowns. Each branch was tagged and individually bagged. Each branch was examined for egg masses as previously described.[2]

D. Percent Defoliation

The sample trees were also used for determination of current year's defoliation. The 6-class system (Parker et al. 1978) was used. This method involved sampling four apical branches: a branch (70 cm in length) from each quadrant at midcrown of each sample tree. On

[2]Egg mass data on seedlings and saplings were collected and analyzed by personnel from the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

each branch sample, 25 new shoots were examined for current defoliation using the left side of one branch and the right side of another, and so on. Each new shoot was individually examined for defoliation and assigned an index and midpoint value as follows:

Defoliation class %	Index value	Midpoint value
0	0	0
1-25	1	12.5
26-50	2	37.5
51-75	3	62.5
76-99	4	87.5
100	5	100

After index values were determined for the branch samples, individual tree defoliation was calculated using the following formula:

$$\% \text{ defoliation} = \frac{(n_1)\ (12.5) + (n_2)\ (37.5) + (n_3)\ (62.5) + (n_4)\ (87.5) + (n_5)\ (100)}{100}$$

Where n_1 = number of twiglets with index value 1
n_2 = number of twiglets with index value 2
n_3 = number of twiglets with index value 3
n_4 = number of twiglets with index value 4
n_5 = number of twiglets with index value 5

Unit defoliation was simply the average of the individual tree values. Two of the four branches used for defoliation determinations were individually bagged, tagged, and transferred to the laboratory for egg mass determinations.

E. Insect Conditions

1. Larval Densities

Larval budworm densities per 100 live buds sampled on overstory, sapling, and seedling sample trees increased substantially on all units in 1981. Distribution of larval instars is shown in table 1. In the treatment units, average larval densities per 100 buds ranged from 22.4 to 32.6 on overstory trees, 13.7 to 41.5 on saplings, and 12.4 to 24.1 on seedlings. Larval densities on the treatment area, as a whole, averaged 26.2, 24, and 17.7, respectively. Larval densities on the control unit were somewhat higher, averaging 37.4 on overstory sample trees and 28.8 on both sapling and seedling sample trees. These data are summarized along with those reported in 1980 in table 2.

TABLE 1. Western spruce budworm larval instar distribution, posttreatment samples, western spruce budworm silvicultural demonstration area project, Carson National Forest, 1981

Treatment units	Sampling date(s)	Number of buds						
		Larval instars					Pupae	Total
		II	III	IV	V	VI		
Control	6/19/81	0	95	107	67	40	0	309
Shelterwood/ advance regeneration	6/19/81	0	38	87	45	42	0	212
Overstory removal	6/20/81	0	13	59	81	59	0	212
Shelterwood/ planting	6/20/81	0	33	54	39	24	0	150
Clearcut	6/20/81	0	--	--	--	--	--	--
Totals		0	179	307	232	165	0	883
Percent		0	20	35	26	19	0	100

2. Egg Mass Densities

Average egg mass densities in budworm-infested mixed conifer stands on the eastern portion of the Carson National Forest, including the recently established western spruce budworm silvicultural demonstration area, declined significantly from 1980 to 1981. In the silviculturally treated units, average egg mass densities declined 80 percent on overstory trees, 86 percent on saplings, and (with the exception of 1 unit that increased from an average of 7.4 to 8.1 egg masses per square meter of foliage) 100 percent on seedling-sized trees. Egg mass densities on individual treatment units ranged from 12.7 to 25.6 on overstory trees and from 2.2 to 5.1 on sapling-sized trees. Egg mass densities on the treatment area as a whole averaged 17.4 on overstory trees and 3.2 on saplings. Egg mass densities also decreased in the control unit. Egg masses declined 78 percent on overstory trees, 75.1 percent on saplings, and 100 percent on seedlings. Egg mass densities in the control unit averaged 24.6 on overstory and 3.4 on sapling-sized trees. Seedlings examined revealed no egg masses. These data are summarized along with those data reported in 1980 in table 3.

TABLE 2. Summaries of pretreatment (1980) and posttreatment larval densities per 100 buds for seedlings, saplings, and overstory Douglas-firs, western spruce budworm silvicultural demonstration area project, Carson National Forest

Treatment unit	Budworm larvae per 100 buds of Douglas-fir											
	Seedlings				Saplings				Overstory		DF	
	1980		1981		1980		1981		1980		1981	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Clearcut	18.2	9.3	1/		14.8	5.9	--1/		15.5	9.1	--1/	
Shelterwood/ plant	12.4	7.2	24.1	12.9	32.7	8.1	13.7	1.6	33.9	13.1	22.4	9.5
Shelterwood/ advanced regeneration	data lost		16.5	6.7	18.9	11.1	41.5	30.6	15.8	7.1	32.6	17.9
Overstory removal	11.5	11.6	12.4	5.7	19.4	15.4	16.9	4.2	22.6	9.7	23.6	6.2
Control	13.6	6.8	28.8	11.3	22.8	10.3	28.8	7.4	21.9	18.8	37.4	18.6

1/ Sapling- and seedling-sized trees were removed by the clearcut treatment.

TABLE 3. Summaries of pretreatment (1980) and posttreatment (1981) egg mass densities per meter square of foliage for seedling, sapling, and overstory Douglas-firs, western spruce budworm silvicultural demonstration area project, Carson National Forest

Treatment Unit	Egg masses per M^2 of foliage											
	Seedlings				Saplings				Overstory		DF	
	1980		1981		1980		1981		1980		1981	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Clearcut	3.1	11.7	[1/]		13.7	15.1	--[1/]		76.6	24.9	--[1/]	
Shelterwood/plant	11.1	24.5	0		30.4	22.6	2.2	4.9	56.7	23.3	25.6	29.0
Shelterwood/ advanced regeneration	7.4	23.4	8.1	17.1	23.4	28.0	2.4	5.2	96.7	42.8	12.7	8.6
Overstory removal	data lost		0		data lost		5.1	8.2	85.4	43.4	13.9	13.9
Control	3.7	6.9	0	0	13.7	15.8	3.4	10.8	111.8	69.9	24.6	15.4

1/ Sapling- and seedling-sized trees were removed by the clearcut treatment.

Although egg mass densities in the areas sampled decreased significantly in 1981, average egg mass densities collected from the dominant-codominant sample trees are still high and indicate that larval densities and subsequent defoliation will continue to occur at moderate to heavy levels in all demonstration units in 1982 (McKnight et al. 1970).

F. Percent Defoliation

Defoliation to dominant-codominant Douglas-fir sample trees increased on all but one treatment unit in 1981 (table 4). Average defoliation for individual treatment units ranged from 80.1 to 94 percent (6-class system) and averaged 85.3 percent for the combined treatment area. Defoliation to dominant-codominant sample trees on the control unit averaged 90.5 percent.

Defoliation on both the treatment units and control unit is expected to remain at similar levels in 1982.

G. Future Monitoring and Evaluation

The western spruce budworm will be sampled annually on each of the five units. Estimates will be made of egg mass and larval density for each tree strata: seedlings, saplings, and dominant-codominant Douglas-fir. Formal stand examinations, including budworm damage assessments, will be made at 2-year intervals beginning the fall after treatments are completed. Logging began on the area in the fall of 1980 and the initial treatments are expected to be installed by spring 1982.

Evaluation of the imposed silvicultural treatments will be made by comparing species composition, stand structure, stocking, growth rate, and incidence of budworm damage between the treatment units. Observed differences cannot be attributed solely to the silvicultural treatment applied, since initial site and stand conditions were variable. However, these observations will provide valuable insight into the feasibility of applying recommended silvicultural strategies for budworm management on specific sites.

Unit No. 5 is to be left untreated and will serve as an example of the development of an unmanaged stand during the course of a spruce budworm outbreak. Insect population trends in this unmanaged stand will be compared to indicated trends in the treated areas to determine the effect of the applied silvicultural treatments on insect densities.

TABLE 4. Pretreatment (1980) and posttreatment (1981) percent defoliation to overstory Douglas-fir sample trees by treatment unit, western spruce budworm silvicultural demonstration area project, Carson National Forest

Treatment unit	Percent defoliation[a/]			
	1980		1981	
	$\bar{x}$	SE	$\bar{x}$	SE
Clearcut	72.3	8.2	--	--
Shelterwood/plant	88.2	6.4	81.7	4.6
Shelterwood/ advanced regeneration	91.1	2.7	94.0	2.0
Overstory removal	76.2	8.9	80.1	4.1
Control	68.8	5.9	90.5	2.6

a/ Each treatment unit percentage is the average defoliation of 10 sample trees.

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